



$$J = \frac{1}{2}$$

## $\mu$ MASS (atomic mass units u)

The primary determination of a muon's mass comes from measuring the ratio of the mass to that of a nucleus, so that the result is obtained in u (atomic mass units). The conversion factor to MeV is more uncertain than the mass of the muon in u. In this datablock we give the result in u, and in the following datablock in MeV.

VALUE (u)	DOCUMENT ID	TECN	COMMENT
<b>0.1134289264±0.000000030</b>	MOHR 05	RVUE	2002 CODATA value
<b>• • • We do not use the following data for averages, fits, limits, etc. • • •</b>			
0.1134289168±0.000000034	<sup>1</sup> MOHR 99	RVUE	1998 CODATA value
0.113428913 ±0.000000017	<sup>2</sup> COHEN 87	RVUE	1986 CODATA value

<sup>1</sup> MOHR 99 make use of other 1998 CODATA entries below.  
<sup>2</sup> COHEN 87 make use of other 1986 CODATA entries below.

## $\mu$ MASS

2002 CODATA gives the conversion factor from u (atomic mass units, see the above datablock) as 931.494 043 (80). Earlier values use the then-current conversion factor. The conversion error dominates the masses given below.

VALUE (MeV)	DOCUMENT ID	TECN	CHG	COMMENT
<b>105.6583692±0.0000094</b>	MOHR 05	RVUE		2002 CODATA value
<b>• • • We do not use the following data for averages, fits, limits, etc. • • •</b>				
105.6583568±0.0000052	MOHR 99	RVUE		1998 CODATA value
105.658353 ±0.000016	<sup>3</sup> COHEN 87	RVUE		1986 CODATA value
105.658386 ±0.000044	<sup>4</sup> MARIAM 82	CNTR	+	
105.65836 ±0.00026	<sup>5</sup> CROWE 72	CNTR		
105.65865 ±0.00044	<sup>6</sup> CRANE 71	CNTR		

<sup>3</sup> Converted to MeV using the 1998 CODATA value of the conversion constant, 931.494013 ± 0.0000037 MeV/u.  
<sup>4</sup> MARIAM 82 give  $m_\mu/m_e = 206.768259(62)$ .  
<sup>5</sup> CROWE 72 give  $m_\mu/m_e = 206.7682(5)$ .  
<sup>6</sup> CRANE 71 give  $m_\mu/m_e = 206.76878(85)$ .

## $\mu$ MEAN LIFE $\tau$

Measurements with an error  $> 0.001 \times 10^{-6}$  s have been omitted.

VALUE ( $10^{-6}$ s)	DOCUMENT ID	TECN	CHG
<b>2.19703 ± 0.00004 OUR AVERAGE</b>			
2.197078 ± 0.000073	BARDIN 84	CNTR	+
2.197025 ± 0.000155	BARDIN 84	CNTR	-
2.19695 ± 0.00006	GIOVANETTI 84	CNTR	+
2.19711 ± 0.00008	BALANDIN 74	CNTR	+
2.1973 ± 0.0003	DUCLOS 73	CNTR	+

## $\tau_{\mu^+}/\tau_{\mu^-}$ MEAN LIFE RATIO

A test of *CPT* invariance.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>1.000024 ± 0.000078</b>			
BARDIN 84	CNTR		
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.0008 ± 0.0010	BAILEY 79	CNTR	Storage ring
1.000 ± 0.001	MEYER 63	CNTR	Mean life $\mu^+/\mu^-$

## $(\tau_{\mu^+} - \tau_{\mu^-}) / \tau_{\text{average}}$

A test of *CPT* invariance. Calculated from the mean-life ratio, above.

VALUE	DOCUMENT ID
<b>(2 ± 8) × 10<sup>-5</sup> OUR EVALUATION</b>	

## $\mu/p$ MAGNETIC MOMENT RATIO

This ratio is used to obtain a precise value of the muon mass and to reduce experimental muon Larmor frequency measurements to the muon magnetic moment anomaly. Measurements with an error  $> 0.00001$  have been omitted. By convention, the minus sign on this ratio is omitted. CODATA values were fitted using their selection of data, plus other data from multiparameter fits.

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
<b>3.183345118 ± 0.000000089</b>	MOHR 05	RVUE		2002 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •				
3.18334513 ± 0.00000039	LIU 99	CNTR	+	HFS in muonium
3.18334539 ± 0.00000010	MOHR 99	RVUE		1998 CODATA value
3.18334547 ± 0.00000047	COHEN 87	RVUE		1986 CODATA value
3.1833441 ± 0.0000017	KLEMPT 82	CNTR	+	Precession strob
3.1833461 ± 0.0000011	MARIAM 82	CNTR	+	HFS splitting

3.1833448	$\pm 0.0000029$	CAMANI	78	CNTR	+	See KLEMPPT 82
3.1833403	$\pm 0.0000044$	CASPERSON	77	CNTR	+	HFS splitting
3.1833402	$\pm 0.0000072$	COHEN	73	RVUE		1973 CODATA value
3.1833467	$\pm 0.0000082$	CROWE	72	CNTR	+	Precession phase

## A REVIEW GOES HERE – Check our WWW List of Reviews

### $\mu$ MAGNETIC MOMENT ANOMALY

The parity-violating decay of muons in a storage ring is observed. The difference frequency  $\omega_a$  between the muon spin precession and the orbital angular frequency  $(e/m_\mu c)\langle B \rangle$  is measured, as is the free proton NMR frequency  $\omega_p$ , thus determining the ratio  $R = \omega_a/\omega_p$ . Given the magnetic moment ratio  $\lambda = \mu_\mu/\mu_p$  (from hyperfine structure in muonium),  $(g-2)/2 = R/(\lambda - R)$ .

$$\mu_\mu/(e\hbar/2m_\mu) - 1 = (g_\mu - 2)/2$$

VALUE (units $10^{-10}$ )		DOCUMENT ID	TECN	CHG	COMMENT	
<b>11659208.0 <math>\pm</math> 5.4 <math>\pm</math> 3.3</b>		BENNETT	06	MUG2	Average $\mu^+$ and $\mu^-$	
<b>• • •</b> We do not use the following data for averages, fits, limits, etc. <b>• • •</b>						
11659208	$\pm 6$	BENNETT	04	MUG2	Average $\mu^+$ and $\mu^-$	
11659214	$\pm 8 \pm 3$	BENNETT	04	MUG2	– Storage ring	
11659203	$\pm 6 \pm 5$	BENNETT	04	MUG2	+ Storage ring	
11659204	$\pm 7 \pm 5$	BENNETT	02	MUG2	+ Storage ring	
11659202	$\pm 14 \pm 6$	BROWN	01	MUG2	+ Storage ring	
11659191	$\pm 59$	BROWN	00	MUG2	+ Storage ring	
11659100	$\pm 110$	7 BAILEY	79	CNTR	+ Storage ring	
11659360	$\pm 120$	7 BAILEY	79	CNTR	– Storage ring	
11659230	$\pm 85$	7 BAILEY	79	CNTR	$\pm$ Storage ring	
11620000	$\pm 5000$	CHARPAK	62	CNTR	+	

<sup>7</sup> BAILEY 79 values recalculated by HUGHES 99 using the COHEN 87  $\mu/p$  magnetic moment. The improved MOHR 99 value does not change the result.

$$(g_{\mu^+} - g_{\mu^-}) / g_{\text{average}}$$

A test of *CPT* invariance.

VALUE (units $10^{-8}$ )		DOCUMENT ID	TECN		
<b>-0.11 <math>\pm</math> 0.12</b>		BENNETT	04	MUG2	
<b>• • •</b> We do not use the following data for averages, fits, limits, etc. <b>• • •</b>					
-2.6 $\pm$ 1.6		BAILEY	79	CNTR	

### $\mu$ ELECTRIC DIPOLE MOMENT

A nonzero value is forbidden by both *T* invariance and *P* invariance.

VALUE ( $10^{-19}$ ecm)		DOCUMENT ID	TECN	CHG	COMMENT	
<b>3.7 <math>\pm</math> 3.4</b>		8 BAILEY	78	CNTR	$\pm$ Storage ring	
<b>• • •</b> We do not use the following data for averages, fits, limits, etc. <b>• • •</b>						
8.6 $\pm$ 4.5		BAILEY	78	CNTR	+	Storage rings
0.8 $\pm$ 4.3		BAILEY	78	CNTR	–	Storage rings

<sup>8</sup> This is the combination of the two BAILEY 78 results given below.

## MUON-ELECTRON CHARGE RATIO ANOMALY $q_{\mu^+}/q_{e^-} + 1$

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
<b>(1.1±2.1) × 10<sup>-9</sup></b>	<sup>9</sup> MEYER	00	CNTR	+ 1s–2s muonium interval

<sup>9</sup> MEYER 00 measure the 1s–2s muonium interval, and then interpret the result in terms of muon-electron charge ratio  $q_{\mu^+}/q_{e^-}$ .

## $\mu^-$ DECAY MODES

$\mu^+$  modes are charge conjugates of the modes below.

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1 e^- \bar{\nu}_e \nu_\mu$	≈ 100%	
$\Gamma_2 e^- \bar{\nu}_e \nu_\mu \gamma$	[a] (1.4±0.4) %	
$\Gamma_3 e^- \bar{\nu}_e \nu_\mu e^+ e^-$	[b] (3.4±0.4) × 10 <sup>-5</sup>	

### Lepton Family number (*LF*) violating modes

$\Gamma_4 e^- \nu_e \bar{\nu}_\mu$	<i>LF</i>	[c] < 1.2	%	90%
$\Gamma_5 e^- \gamma$	<i>LF</i>	< 1.2	× 10 <sup>-11</sup>	90%
$\Gamma_6 e^- e^+ e^-$	<i>LF</i>	< 1.0	× 10 <sup>-12</sup>	90%
$\Gamma_7 e^- 2\gamma$	<i>LF</i>	< 7.2	× 10 <sup>-11</sup>	90%

[a] This only includes events with the  $\gamma$  energy > 10 MeV. Since the  $e^- \bar{\nu}_e \nu_\mu$  and  $e^- \bar{\nu}_e \nu_\mu \gamma$  modes cannot be clearly separated, we regard the latter mode as a subset of the former.

[b] See the Particle Listings below for the energy limits used in this measurement.

[c] A test of additive vs. multiplicative lepton family number conservation.

## $\mu^-$ BRANCHING RATIOS

$\Gamma(e^- \bar{\nu}_e \nu_\mu \gamma)/\Gamma_{\text{total}}$			$\Gamma_2/\Gamma$	
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.014 ±0.004</b>		CRITTENDEN 61	CNTR	$\gamma$ KE > 10 MeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
862	BOGART	67	CNTR	$\gamma$ KE > 14.5 MeV
0.0033±0.0013		CRITTENDEN 61	CNTR	$\gamma$ KE > 20 MeV
27	ASHKIN	59	CNTR	

### $\Gamma(e^- \bar{\nu}_e \nu_\mu e^+ e^-)/\Gamma_{\text{total}}$

### $\Gamma_3/\Gamma$

VALUE (units $10^{-5}$ )	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>3.4±0.2±0.3</b>	7443	10 BERTL	85	SPEC +	SINDRUM
<b>• • •</b> We do not use the following data for averages, fits, limits, etc. <b>• • •</b>					
2.2±1.5	7	11 CRITTENDEN	61	HLBC +	$E(e^+ e^-) > 10$ MeV
2	1	12 GUREVICH	60	EMUL +	
1.5±1.0	3	13 LEE	59	HBC +	

<sup>10</sup> BERTL 85 has transverse momentum cut  $p_T > 17$  MeV/c. Systematic error was increased by us.

<sup>11</sup> CRITTENDEN 61 count only those decays where total energy of either ( $e^+$ ,  $e^-$ ) combination is  $> 10$  MeV.

<sup>12</sup> GUREVICH 60 interpret their event as either virtual or real photon conversion.  $e^+$  and  $e^-$  energies not measured.

<sup>13</sup> In the three LEE 59 events, the sum of energies  $E(e^+) + E(e^-) + E(e^+)$  was 51 MeV, 55 MeV, and 33 MeV.

### $\Gamma(e^- \nu_e \bar{\nu}_\mu)/\Gamma_{\text{total}}$

### $\Gamma_4/\Gamma$

Forbidden by the additive conservation law for lepton family number. A multiplicative law predicts this branching ratio to be 1/2. For a review see NEMETHY 81.

VALUE	CL%	DOCUMENT ID	TECN	CHG	COMMENT
<b>&lt; 0.012</b>	90	14 FREEDMAN	93	CNTR +	$\nu$ oscillation search

**• • •** We do not use the following data for averages, fits, limits, etc. **• • •**

< 0.018 90 KRAKAUER 91B CALO +

< 0.05 90 15 BERGSMA 83 CALO  $\bar{\nu}_\mu e \rightarrow \mu^- \bar{\nu}_e$

< 0.09 90 JONKER 80 CALO See BERGSMA 83

-0.001±0.061 WILLIS 80 CNTR +

0.13 ± 0.15 BLIETSCHAU 78 HLBC ± Avg. of 4 values

< 0.25 90 EICHTEN 73 HLBC +

<sup>14</sup> FREEDMAN 93 limit on  $\bar{\nu}_e$  observation is here interpreted as a limit on lepton family number violation.

<sup>15</sup> BERGSMA 83 gives a limit on the inverse muon decay cross-section ratio  $\sigma(\bar{\nu}_\mu e^- \rightarrow \mu^- \bar{\nu}_e)/\sigma(\nu_\mu e^- \rightarrow \mu^- \nu_e)$ , which is essentially equivalent to  $\Gamma(e^- \nu_e \bar{\nu}_\mu)/\Gamma_{\text{total}}$  for small values like that quoted.

### $\Gamma(e^- \gamma)/\Gamma_{\text{total}}$

### $\Gamma_5/\Gamma$

Forbidden by lepton family number conservation.

VALUE (units $10^{-11}$ )	CL%	DOCUMENT ID	TECN	CHG	COMMENT
<b>&lt; 1.2</b>	90	BROOKS	99	SPEC +	LAMPF

**• • •** We do not use the following data for averages, fits, limits, etc. **• • •**

< 1.2 90 AHMED 02 SPEC + MEGA

< 4.9 90 BOLTON 88 CBOX + LAMPF

<100 90 AZUELOS 83 CNTR + TRIUMF

< 17 90 KINNISON 82 SPEC + LAMPF

<100 90 SCHAAF 80 ELEC + SIN

### $\Gamma(e^- e^+ e^-)/\Gamma_{\text{total}}$

Forbidden by lepton family number conservation.

VALUE (units $10^{-12}$ )	CL%	DOCUMENT ID	TECN	CHG	COMMENT
< 1.0	90	16 BELLGARDT	88	SPEC +	SINDRUM
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
< 36	90	BARANOV	91	SPEC +	ARES
< 35	90	BOLTON	88	CBOX +	LAMPF
< 2.4	90	16 BERTL	85	SPEC +	SINDRUM
<160	90	16 BERTL	84	SPEC +	SINDRUM
<130	90	16 BOLTON	84	CNTR	LAMPF

<sup>16</sup> These experiments assume a constant matrix element.

### $\Gamma(e^- 2\gamma)/\Gamma_{\text{total}}$

Forbidden by lepton family number conservation.

VALUE (units $10^{-11}$ )	CL%	DOCUMENT ID	TECN	CHG	COMMENT
< 7.2	90	BOLTON	88	CBOX +	LAMPF
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
< 840	90	17 AZUELOS	83	CNTR +	TRIUMF
<5000	90	18 BOWMAN	78	CNTR	DEPOMMIER 77 data

<sup>17</sup> AZUELOS 83 uses the phase space distribution of BOWMAN 78.

<sup>18</sup> BOWMAN 78 assumes an interaction Lagrangian local on the scale of the inverse  $\mu$  mass.

## LIMIT ON $\mu^- \rightarrow e^-$ CONVERSION

Forbidden by lepton family number conservation.

### $\sigma(\mu^- 32S \rightarrow e^- 32S) / \sigma(\mu^- 32S \rightarrow \nu_\mu 32P^*)$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<7 $\times 10^{-11}$	90	BADERT...	80	STRC SIN
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$				
<4 $\times 10^{-10}$	90	BADERT...	77	STRC SIN

### $\sigma(\mu^- Cu \rightarrow e^- Cu) / \sigma(\mu^- Cu \rightarrow \text{capture})$

VALUE	CL%	DOCUMENT ID	TECN
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$			
<1.6 $\times 10^{-8}$	90	BRYMAN	72

### $\sigma(\mu^- Ti \rightarrow e^- Ti) / \sigma(\mu^- Ti \rightarrow \text{capture})$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<4.3 $\times 10^{-12}$	90	19 DOHMHEN	93	SPEC SINDRUM II
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$				
<4.6 $\times 10^{-12}$	90	AHMAD	88	TPC TRIUMF
<1.6 $\times 10^{-11}$	90	BRYMAN	85	TPC TRIUMF

<sup>19</sup> DOHMHEN 93 assumes  $\mu^- \rightarrow e^-$  conversion leaves the nucleus in its ground state, a process enhanced by coherence and expected to dominate.

### $\sigma(\mu^- \text{Pb} \rightarrow e^- \text{Pb}) / \sigma(\mu^- \text{Pb} \rightarrow \text{capture})$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<4.6 \times 10^{-11}$	90	HONECKER 96	SPEC	SINDRUM II
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$				
$<4.9 \times 10^{-10}$	90	AHMAD 88	TPC	TRIUMF

### $\sigma(\mu^- \text{Au} \rightarrow e^- \text{Au}) / \sigma(\mu^- \text{Au} \rightarrow \text{capture})$

VALUE	CL%	DOCUMENT ID	TECN	CHG	COMMENT
$<7 \times 10^{-13}$	90	BERTL 06	SPEC	-	SINDRUM II

## LIMIT ON $\mu^- \rightarrow e^+$ CONVERSION

Forbidden by total lepton number conservation.

### $\sigma(\mu^- {}^{32}\text{S} \rightarrow e^+ {}^{32}\text{Si}^*) / \sigma(\mu^- {}^{32}\text{S} \rightarrow \nu_\mu {}^{32}\text{P}^*)$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<9 \times 10^{-10}$	90	BADERT... 80	STRC	SIN
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$				
$<1.5 \times 10^{-9}$	90	BADERT... 78	STRC	SIN

### $\sigma(\mu^- {}^{127}\text{I} \rightarrow e^+ {}^{127}\text{Sb}^*) / \sigma(\mu^- {}^{127}\text{I} \rightarrow \text{anything})$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<3 \times 10^{-10}$	90	ABELA 80	CNTR	Radiochemical tech.

<sup>20</sup> ABELA 80 is upper limit for  $\mu^- e^+$  conversion leading to particle-stable states of  ${}^{127}\text{Sb}$ . Limit for total conversion rate is higher by a factor less than 4 (G. Backenstoss, private communication).

### $\sigma(\mu^- \text{Cu} \rightarrow e^+ \text{Co}) / \sigma(\mu^- \text{Cu} \rightarrow \nu_\mu \text{Ni})$

VALUE	CL%	DOCUMENT ID	TECN
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$			
$<2.6 \times 10^{-8}$	90	BRYMAN 72	SPEC
$<2.2 \times 10^{-7}$	90	CONFORTO 62	OSPK

### $\sigma(\mu^- \text{Ti} \rightarrow e^+ \text{Ca}) / \sigma(\mu^- \text{Ti} \rightarrow \text{capture})$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
$<3.6 \times 10^{-11}$	90	1	KAULARD 98	SPEC	-	SINDRUM II
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$						
$<1.7 \times 10^{-12}$	90	1	KAULARD 98	SPEC	-	SINDRUM II
$<4.3 \times 10^{-12}$	90	23	DOHMHEN 93	SPEC		SINDRUM II
$<8.9 \times 10^{-11}$	90	21	DOHMHEN 93	SPEC		SINDRUM II
$<1.7 \times 10^{-10}$	90	24	AHMAD 88	TPC		TRIUMF

<sup>21</sup> This limit assumes a giant resonance excitation of the daughter Ca nucleus (mean energy and width both 20 MeV).

<sup>22</sup> KAULARD 98 obtained these same limits using the unified classical analysis of FELDMAN 98.

<sup>23</sup> This limit assumes the daughter Ca nucleus is left in the ground state. However, the probability of this is unknown.

<sup>24</sup> Assuming a giant-resonance-excitation model.

## LIMIT ON MUONIUM → ANTIMUONIUM CONVERSION

Forbidden by lepton family number conservation.

$$R_g = G_C / G_F$$

The effective Lagrangian for the  $\mu^+ e^- \rightarrow \mu^- e^+$  conversion is assumed to be

$$\mathcal{L} = 2^{-1/2} G_C [\bar{\psi}_\mu \gamma_\lambda (1 - \gamma_5) \psi_e] [\bar{\psi}_\mu \gamma_\lambda (1 - \gamma_5) \psi_e] + \text{h.c.}$$

The experimental result is then an upper limit on  $G_C/G_F$ , where  $G_F$  is the Fermi coupling constant.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
< <b>0.0030</b>	90	1	25 WILLMANN	99	SPEC	+ $\mu^+$ at 26 GeV/c
<b>• • •</b> We do not use the following data for averages, fits, limits, etc. <b>• • •</b>						
< 0.14	90	1	26 GORDEEV	97	SPEC	+ JINR phasotron
< 0.018	90	0	27 ABELA	96	SPEC	+ $\mu^+$ at 24 MeV
< 6.9	90		NI	93	CBOX	LAMPF
< 0.16	90		MATTHIAS	91	SPEC	LAMPF
< 0.29	90		HUBER	90B	CNTR	TRIUMF
< 20	95		BEER	86	CNTR	TRIUMF
< 42	95		MARSHALL	82	CNTR	

<sup>25</sup> WILLMANN 99 quote both probability  $P_{MM} < 8.3 \times 10^{-11}$  at 90% CL in a 0.1 T field and  $R_g = G_C/G_F$ .

<sup>26</sup> GORDEEV 97 quote limits on both  $f = G_{MM}/G_F$  and the probability  $W_{MM} < 4.7 \times 10^{-7}$  (90% CL).

<sup>27</sup> ABELA 96 quote both probability  $P_{MM} < 8 \times 10^{-9}$  at 90% CL and  $R_g = G_C/G_F$ .

A REVIEW GOES HERE – Check our WWW List of Reviews

## $\mu$ DECAY PARAMETERS

### $\rho$ PARAMETER

( $V-A$ ) theory predicts  $\rho = 0.75$ .

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>0.7509 ± 0.0010 OUR AVERAGE</b>					
0.75080 ± 0.00032 ± 0.00100	6G	28 MUSSER	05	SPEC	+ surface $\mu^+$ at TRIUMF
0.7518 ± 0.0026		DERENZO	69	RVUE	
<b>• • •</b> We do not use the following data for averages, fits, limits, etc. <b>• • •</b>					
0.72 ± 0.06 ± 0.08		AMORUSO	04	ICAR	Liquid Ar TPC
0.762 ± 0.008	170k	29 FRYBERGER	68	ASPK	+ 25–53 MeV $e^+$
0.760 ± 0.009	280k	29 SHERWOOD	67	ASPK	+ 25–53 MeV $e^+$
0.7503 ± 0.0026	800k	29 PEOPLES	66	ASPK	+ 20–53 MeV $e^+$

<sup>28</sup> The quoted systematic error includes a contribution of 0.00023 (added in quadrature) from the dependence on the Michel parameter  $\eta$ .

<sup>29</sup>  $\eta$  constrained = 0. These values incorporated into a two parameter fit to  $\rho$  and  $\eta$  by DERENZO 69.

## $\eta$ PARAMETER

( $V-A$ ) theory predicts  $\eta = 0$ .

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>0.001 ± 0.024 OUR AVERAGE</b>		Error includes scale factor of 2.0. See the ideogram below.			

0.071 ± 0.037	± 0.005	30M	DANNEBERG	05	CNTR	+	7–53 MeV $e^+$
-0.007 ± 0.013		5.3M	BURKARD	85B	FIT	+	9–53 MeV $e^+$
-0.12 ± 0.21		6346	DERENZO	69	HBC	+	1.6–6.8 MeV $e^+$

• • • We do not use the following data for averages, fits, limits, etc. • • •

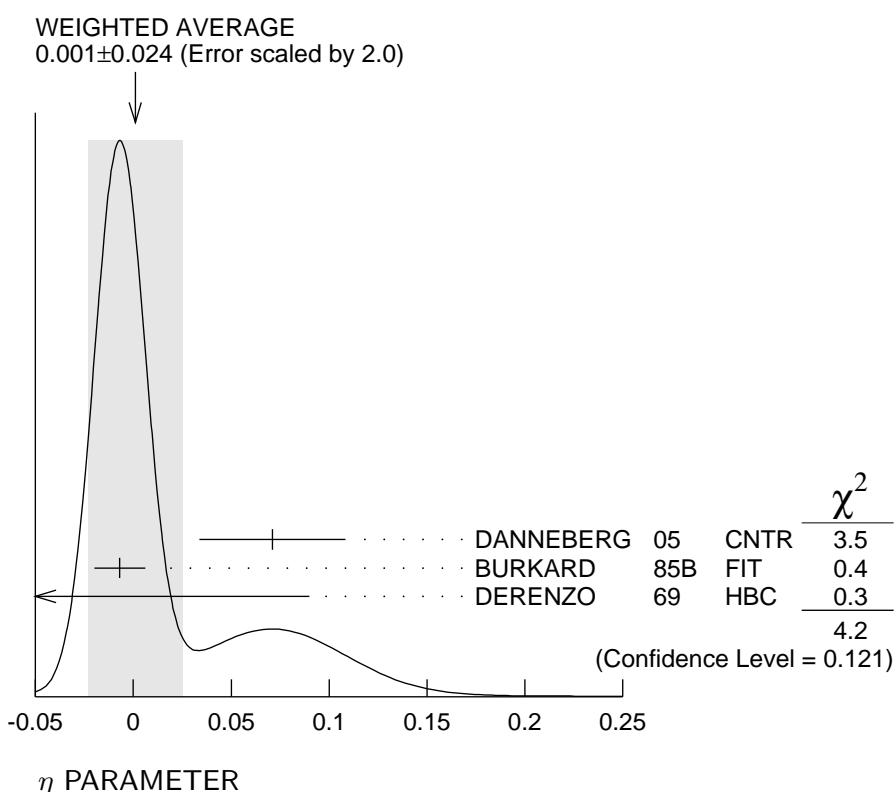
-0.0021 ± 0.0070 ± 0.0010	30M	31 DANNEBERG	05	CNTR	+	7–53 MeV $e^+$
-0.012 ± 0.015 ± 0.003	5.3M	31 BURKARD	85B	CNTR	+	9–53 MeV $e^+$
0.011 ± 0.081 ± 0.026	5.3M	BURKARD	85B	CNTR	+	9–53 MeV $e^+$
-0.7 ± 0.5	170k	32 FRYBERGER	68	ASPK	+	25–53 MeV $e^+$
-0.7 ± 0.6	280k	32 SHERWOOD	67	ASPK	+	25–53 MeV $e^+$
0.05 ± 0.5	800k	32 PEOPLES	66	ASPK	+	20–53 MeV $e^+$
-2.0 ± 0.9	9213	33 PLANO	60	HBC	+	Whole spectrum

30 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

31  $\alpha = \alpha' = 0$  assumed.

32  $\rho$  constrained = 0.75.

33 Two parameter fit to  $\rho$  and  $\eta$ ; PLANO 60 discounts value for  $\eta$ .



## $\delta$ PARAMETER

( $V-A$ ) theory predicts  $\delta = 0.75$ .

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>0.7495 ±0.0012 OUR AVERAGE</b>					
0.74964 ±0.00066 ±0.00112	6G	GAPONENKO 05	SPEC	+	surface $\mu^+$ at TRIUMF
0.7486 ±0.0026 ±0.0028	34 BALKE	88	SPEC	+	Surface $\mu^+$ 's
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.752 ±0.009	490k	VOSSLER 69	FRYBERGER 68	ASPK	+ 25–53 MeV $e^+$
0.782 ±0.031		KRUGER 61			
0.78 ±0.05	8354	PLANO 60	HBC	+	Whole spectrum

<sup>34</sup> BALKE 88 uses  $\rho = 0.752 \pm 0.003$ .

<sup>35</sup> VOSSLER 69 has measured the asymmetry below 10 MeV. See comments about radiative corrections in VOSSLER 69.

## $|(\xi \text{ PARAMETER}) \times (\mu \text{ LONGITUDINAL POLARIZATION})|$

( $V-A$ ) theory predicts  $\xi = 1$ , longitudinal polarization = 1.

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>1.0007±0.0035 OUR AVERAGE</b>					
1.0003 ±0.0006 ±0.0038		JAMIESON 06	TWST	+	surface $\mu^+$ beam
1.0027 ±0.0079 ±0.0030		BELTRAMI 87	CNTR		SIN, $\pi$ decay in flight
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.0013 ±0.0030 ±0.0053	36 IMAZATO	92	SPEC	+	$K^+ \rightarrow \mu^+ \nu_\mu$
0.975 ±0.015		AKHMANOV 68	EMUL		140 kG
0.975 ±0.030	66k	GUREVICH 64	EMUL		See AKHMANOV 68
0.903 ±0.027	37 ALI-ZADE	61	EMUL	+	27 kG
0.93 ±0.06	8354	PLANO 60	HBC	+	8.8 kG
0.97 ±0.05	9k	BARDON 59	CNTR		Bromoform target

<sup>36</sup> The corresponding 90% confidence limit from IMAZATO 92 is  $|\xi P_\mu| > 0.990$ . This measurement is of  $K^+$  decay, not  $\pi^+$  decay, so we do not include it in an average, nor do we yet set up a separate data block for  $K$  results.

<sup>37</sup> Depolarization by medium not known sufficiently well.

## $\xi \times (\mu \text{ LONGITUDINAL POLARIZATION}) \times \delta / \rho$

VALUE	CL%	DOCUMENT ID	TECN	CHG	COMMENT
>0.99682	90	38 JODIDIO	86	SPEC	+
TRIUMF					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
>0.9966	90	39 STOKER	85	SPEC	+
>0.9959	90	CARR	83	SPEC	+
					μ-spin rotation
					11 kG

<sup>38</sup> JODIDIO 86 includes data from CARR 83 and STOKER 85. The value here is from the erratum.

<sup>39</sup> STOKER 85 find  $(\xi P_\mu \delta / \rho) > 0.9955$  and  $> 0.9966$ , where the first limit is from new  $\mu$  spin-rotation data and the second is from combination with CARR 83 data. In  $V-A$  theory,  $(\delta / \rho) = 1.0$ .

## $\xi'$ = LONGITUDINAL POLARIZATION OF $e^+$

( $V-A$ ) theory predicts the longitudinal polarization =  $\pm 1$  for  $e^\pm$ , respectively. We have flipped the sign for  $e^-$  so our programs can average.

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>1.00 ± 0.04 OUR AVERAGE</b>					
0.998 ± 0.045	1M	BURKARD	85	CNTR +	Bhabha + annihil
0.89 ± 0.28	29k	SCHWARTZ	67	OSPK -	Moller scattering
0.94 ± 0.38		BLOOM	64	CNTR +	Brems. transmiss.
1.04 ± 0.18		DUCLOS	64	CNTR +	Bhabha scattering
1.05 ± 0.30		BUHLER	63	CNTR +	Annihilation

## $\xi''$ PARAMETER

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>0.65 ± 0.36</b>					
40	326k	BURKARD	85	CNTR +	Bhabha + annihil

40 BURKARD 85 measure  $(\xi'' - \xi\xi')/\xi$  and  $\xi'$  and set  $\xi = 1$ .

## TRANSVERSE $e^+$ POLARIZATION IN PLANE OF $\mu$ SPIN, $e^+$ MOMENTUM

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>7 ± 8 OUR AVERAGE</b>					
6.3 ± 7.7 ± 3.4	30M	DANNEBERG	05	CNTR +	7-53 MeV $e^+$
16 ± 21 ± 10	5.3M	BURKARD	85B	CNTR +	Annihil 9-53 MeV

## TRANSVERSE $e^+$ POLARIZATION NORMAL TO PLANE OF $\mu$ SPIN, $e^+$ MOMENTUM

Zero if  $T$  invariance holds.

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>-2 ± 8 OUR AVERAGE</b>					
-3.7 ± 7.7 ± 3.4	30M	DANNEBERG	05	CNTR +	7-53 MeV $e^+$
7 ± 22 ± 7	5.3M	BURKARD	85B	CNTR +	Annihil 9-53 MeV

## $\alpha/A$

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>0.4 ± 4.3</b>					
41	BURKARD 85B	FIT			

• • • We do not use the following data for averages, fits, limits, etc. • • •

15 ± 50 ± 14 5.3M BURKARD 85B CNTR + 9-53 MeV  $e^+$

41 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

## $\alpha'/A$

Zero if  $T$  invariance holds.

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>0 ± 4 OUR AVERAGE</b>					
- 3.4 ± 21.3 ± 4.9	30M	DANNEBERG	05	CNTR +	7-53 MeV $e^+$

- 0.2 ± 4.3 BURKARD 85B FIT

• • • We do not use the following data for averages, fits, limits, etc. • • •

-47 ± 50 ± 14 5.3M BURKARD 85B CNTR + 9-53 MeV  $e^+$

42 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

43 BURKARD 85B measure  $e^+$  polarizations  $P_{T_1}$  and  $P_{T_2}$  versus  $e^+$  energy.

## $\beta/A$

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
<b><math>3.9 \pm 6.2</math></b>		44 BURKARD	85B	FIT	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
2 $\pm 17$ $\pm 6$	5.3M	BURKARD	85B	CNTR +	9–53 MeV $e^+$
44 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.					

## $\beta'/A$

Zero if  $T$  invariance holds.

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
<b>1 <math>\pm 5</math> OUR AVERAGE</b>					
– $0.5 \pm 7.8 \pm 1.8$	30M	DANNEBERG	05	CNTR +	7–53 MeV $e^+$
1.5 $\pm 6.3$		45 BURKARD	85B	FIT	
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$					
– $1.3 \pm 3.5 \pm 0.6$	30M	46 DANNEBERG	05	CNTR +	7–53 MeV $e^+$
17 $\pm 17$ $\pm 6$	5.3M	47 BURKARD	85B	CNTR +	9–53 MeV $e^+$
45 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.					
46 $\alpha = \alpha' = 0$ assumed.					
47 BURKARD 85B measure $e^+$ polarizations $P_{T_1}$ and $P_{T_2}$ versus $e^+$ energy.					

## $a/A$

This comes from an alternative parameterization to that used in the Summary Table (see the “Note on Muon Decay Parameters” above).

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$			
<15.9	90	48 BURKARD	85B
48 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.			

## $a'/A$

This comes from an alternative parameterization to that used in the Summary Table (see the “Note on Muon Decay Parameters” above).

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$		
5.3 $\pm 4.1$	49 BURKARD	85B
49 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.		

## $(b+b)/A$

This comes from an alternative parameterization to that used in the Summary Table (see the “Note on Muon Decay Parameters” above).

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$			
<1.04	90	50 BURKARD	85B
50 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.			

**c/A**

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above).

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
---	------------	--------------------	-------------

• • • We do not use the following data for averages, fits, limits, etc. • • •

<6.4                    90            51 BURKARD    85B FIT

51 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

**c'/A**

This comes from an alternative parameterization to that used in the Summary Table (see the "Note on Muon Decay Parameters" above).

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
---	--------------------	-------------

• • • We do not use the following data for averages, fits, limits, etc. • • •

$3.5 \pm 2.0$                 52 BURKARD    85B FIT

52 Global fit to all measured parameters. Correlation coefficients are given in BURKARD 85B.

 **$\bar{\eta}$  PARAMETER**

( $V-A$ ) theory predicts  $\bar{\eta} = 0$ .  $\bar{\eta}$  affects spectrum of radiative muon decay.

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
<b>0.02 ±0.08 OUR AVERAGE</b>				
-0.014±0.090	EICHENBER... 84	ELEC	+	$\rho$ free
+0.09 ±0.14	BOGART 67	CNTR	+	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
-0.035±0.098	EICHENBER... 84	ELEC	+	$\rho=0.75$ assumed

 **$\mu$  REFERENCES**

BENNETT	06	PR D73 072003	G.W. Bennett <i>et al.</i>	(MUG-2 Collab.)
BERTL	06	EPJ C47 337	W. Bertl <i>et al.</i>	(SINDRUM II Collab.)
JAMIESON	06	PR D74 072007	B. Jamieson <i>et al.</i>	(TWIST Collab.)
DANNEBERG	05	PRL 94 021802	N. Danneberg <i>et al.</i>	(ETH, JAGL, PSI+)
GAPONENKO	05	PR D71 071101R	A. Gaponenko <i>et al.</i>	(TWIST Collab.)
MOHR	05	RMP 77 1	P.J. Mohr, B.N. Taylor	(NIST)
MUSSER	05	PRL 94 101805	J.R. Musser <i>et al.</i>	(TWIST Collab.)
AMORUSO	04	EPJ C33 233	S. Amoruso <i>et al.</i>	(ICARUS Collab.)
BENNETT	04	PRL 92 161802	G.W. Bennett <i>et al.</i>	(Muon(g-2) Collab.)
AHMED	02	PR D65 112002	M. Ahmed <i>et al.</i>	(MEGA Collab.)
BENNETT	02	PRL 89 101804	G.W. Bennett <i>et al.</i>	(Muon(g-2) Collab.)
BROWN	01	PRL 86 2227	H.N. Brown <i>et al.</i>	(Muon(g-2) Collab.)
BROWN	00	PR D62 091101R	H.N. Brown <i>et al.</i>	(BNL/G-2 Collab.)
MEYER	00	PRL 84 1136	V. Meyer <i>et al.</i>	
BROOKS	99	PRL 83 1521	M.L. Brooks <i>et al.</i>	(MEGA/LAMPF Collab.)
HUGHES	99	RMP 71 S133	V.W. Hughes, T. Kinoshita	
LIU	99	PRL 82 711	W. Liu <i>et al.</i>	(LAMPF Collab.)
MOHR	99	JPCRD 28 1713	P.J. Mohr, B.N. Taylor	(NIST)
Also		RMP 72 351	P.J. Mohr, B.N. Taylor	(NIST)
WILLMANN	99	PRL 82 49	L. Willmann <i>et al.</i>	
FELDMAN	98	PR D57 3873	G.J. Feldman, R.D. Cousins	
KAULARD	98	PL B422 334	J. Kaulard <i>et al.</i>	(SINDRUM-II Collab.)
GORDEEV	97	PAN 60 1164	V.A. Gordeev <i>et al.</i>	(PNPI)

Translated from YAF 60 1291.

ABELA	96	PRL 77 1950	R. Abela <i>et al.</i>	(PSI, ZURI, HEIDH, TBIL+)
HONECKER	96	PRL 76 200	W. Honecker <i>et al.</i>	(SINDRUM II Collab.)
DOHMHEN	93	PL B317 631	C. Dohmen <i>et al.</i>	(PSI SINDRUM-II Collab.)
FREEDMAN	93	PR D47 811	S.J. Freedman <i>et al.</i>	(LAMPF E645 Collab.)
NI	93	PR D48 1976	B. Ni <i>et al.</i>	(LAMPF Crystal-Box Collab.)
IMAZATO	92	PRL 69 877	J. Imazato <i>et al.</i>	(KEK, INUS, TOKY+)
BARANOV	91	SJNP 53 802	V.A. Baranov <i>et al.</i>	(JINR)
		Translated from YAF 53 1302.		
KRAKAUER	91B	PL B263 534	D.A. Krakauer <i>et al.</i>	(UMD, UCI, LANL)
MATTHIAS	91	PRL 66 2716	B.E. Matthias <i>et al.</i>	(YALE, HEIDP, WILL+)
Also		PRL 67 932 (erratum)	B.E. Matthias <i>et al.</i>	(YALE, HEIDP, WILL+)
HUBER	90B	PR D41 2709	T.M. Huber <i>et al.</i>	(WYOM, VICT, ARIZ+)
AHMAD	88	PR D38 2102	S. Ahmad <i>et al.</i>	(TRIU, VICT, VPI, BRCO+)
Also		PRL 59 970	S. Ahmad <i>et al.</i>	(TRIU, VPI, VICT, BRCO+)
BALKE	88	PR D37 587	B. Balke <i>et al.</i>	(LBL, UCB, COLO, NWES+)
BELLGARDT	88	NP B299 1	U. Bellgardt <i>et al.</i>	(SINDRUM Collab.)
BOLTON	88	PR D38 2077	R.D. Bolton <i>et al.</i>	(LANL, STAN, CHIC+)
Also		PRL 56 2461	R.D. Bolton <i>et al.</i>	(LANL, STAN, CHIC+)
Also		PRL 57 3241	D. Grosnick <i>et al.</i>	(CHIC, LANL, STAN+)
BELTRAMI	87	PL B194 326	I. Beltrami <i>et al.</i>	(ETH, SIN, MANZ)
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)
BEER	86	PRL 57 671	G.A. Beer <i>et al.</i>	(VICT, TRIU, WYOM)
JODIDIO	86	PR D34 1967	A. Jodidio <i>et al.</i>	(LBL, NWES, TRIU)
Also		PR D37 237 (erratum)	A. Jodidio <i>et al.</i>	(LBL, NWES, TRIU)
BERTL	85	NP B260 1	W. Bertl <i>et al.</i>	(SINDRUM Collab.)
BRYMAN	85	PRL 55 465	D.A. Bryman <i>et al.</i>	(TRIU, CNRC, BRCO+)
BURKARD	85	PL 150B 242	H. Burkhardt <i>et al.</i>	(ETH, SIN, MANZ)
BURKARD	85B	PL 160B 343	H. Burkhardt <i>et al.</i>	(ETH, SIN, MANZ)
Also		PR D24 2004	F. Corriveau <i>et al.</i>	(ETH, SIN, MANZ)
Also		PL 129B 260	F. Corriveau <i>et al.</i>	(ETH, SIN, MANZ)
STOKER	85	PRL 54 1887	D.P. Stoker <i>et al.</i>	(LBL, NWES, TRIU)
BARDIN	84	PL 137B 135	G. Bardin <i>et al.</i>	(SACL, CERN, BGNA, FIRZ)
BERTL	84	PL 140B 299	W. Bertl <i>et al.</i>	(SINDRUM Collab.)
BOLTON	84	PRL 53 1415	R.D. Bolton <i>et al.</i>	(LANL, CHIC, STAN+)
EICHENBER...	84	NP A412 523	W. Eichenberger, R. Engfer, A. van der Schaff	
GIOVANETTI	84	PR D29 343	K.L. Giovanetti <i>et al.</i>	(WILL)
AZUELOS	83	PRL 51 164	G. Azuelos <i>et al.</i>	(MONT, TRIU, BRCO)
Also		PRL 39 1113	P. Depommier <i>et al.</i>	(MONT, BRCO, TRIU+)
BERGSMA	83	PL 122B 465	F. Bergsma <i>et al.</i>	(CHARM Collab.)
CARR	83	PRL 51 627	J. Carr <i>et al.</i>	(LBL, NWES, TRIU)
KINNISON	82	PR D25 2846	W.W. Kinnison <i>et al.</i>	(IFI, STAN, LANL)
Also		PRL 42 556	J.D. Bowman <i>et al.</i>	(LASL, EFI, STAN)
KLEMPPT	82	PR D25 652	E. Klempert <i>et al.</i>	(MANZ, ETH)
MARIAM	82	PRL 49 993	F.G. Mariam <i>et al.</i>	(YALE, HEIDH, BERN)
MARSHALL	82	PR D25 1174	G.M. Marshall <i>et al.</i>	(BRCO)
NEMETHY	81	CNPP 10 147	P. Nemethy, V.W. Hughes	(LBL, YALE)
ABELA	80	PL 95B 318	R. Abela <i>et al.</i>	(BASL, KARLK, KARLE)
BADERT...	80	LNC 28 401	A. Badertscher <i>et al.</i>	(BERN)
Also		NP A377 406	A. Badertscher <i>et al.</i>	(BERN)
JONKER	80	PL 93B 203	M. Jonker <i>et al.</i>	(CHARM Collab.)
SCHAAF	80	NP A340 249	A. van der Schaaf <i>et al.</i>	(ZURI, ETH+)
Also		PL 72B 183	H.P. Povel <i>et al.</i>	(ZURI, ETH, SIN)
WILLIS	80	PRL 44 522	S.E. Willis <i>et al.</i>	(YALE, LBL, LASL+)
Also		PRL 45 1370	S.E. Willis <i>et al.</i>	(YALE, LBL, LASL+)
BAILEY	79	NP B150 1	J.M. Bailey	(CERN, DARE, MANZ)
BADERT...	78	PL 79B 371	A. Badertscher <i>et al.</i>	(BERN)
BAILEY	78	JPG 4 345	J.M. Bailey	(DARE, BERN, SHEF, MANZ, RMCS+)
Also		NP B150 1	J.M. Bailey	(CERN, DARE, MANZ)
BLIETSCHAU	78	NP B133 205	J. Blietschau <i>et al.</i>	(Gargamelle Collab.)
BOWMAN	78	PRL 41 442	J.D. Bowman <i>et al.</i>	(LASL, IAS, CMU+)
CAMANI	78	PL 77B 326	M. Camani <i>et al.</i>	(ETH, MANZ)
BADERT...	77	PRL 39 1385	A. Badertscher <i>et al.</i>	(BERN)
CASPERSON	77	PRL 38 956	D.E. Casperson <i>et al.</i>	(BERN, HEIDH, LASL+)
DEPOMMIER	77	PRL 39 1113	P. Depommier <i>et al.</i>	(MONT, BRCO, TRIU+)
BALANDIN	74	JETP 40 811	M.P. Balandin <i>et al.</i>	(JINR)
		Translated from ZETF 67 1631.		
COHEN	73	JPCRD 2 664	E.R. Cohen, B.N. Taylor	(RISC, NBS)
DUCLOS	73	PL 47B 491	J. Duclos, A. Magnon, J. Picard	(SACL)
EICHTEN	73	PL 46B 281	T. Eichten <i>et al.</i>	(Gargamelle Collab.)
BRYMAN	72	PRL 28 1469	D.A. Bryman <i>et al.</i>	(VPI)
CROWE	72	PR D5 2145	K.M. Crowe <i>et al.</i>	(LBL, WASH)

CRANE	71	PRL 27 474	T. Crane <i>et al.</i>	(YALE)
DERENZO	69	PR 181 1854	S.E. Derenzo	(EFI)
VOSSLER	69	NC 63A 423	C. Vossler	(EFI)
AKHMANOV	68	SJNP 6 230	V.V. Akhmanov <i>et al.</i>	(KIAE)
		Translated from YAF 6 316.		
FRYBERGER	68	PR 166 1379	D. Fryberger	(EFI)
BOGART	67	PR 156 1405	E. Bogart <i>et al.</i>	(COLU)
SCHWARTZ	67	PR 162 1306	D.M. Schwartz	(EFI)
SHERWOOD	67	PR 156 1475	B.A. Sherwood	(EFI)
PEOPLES	66	Nevis 147 unpub.	J. Peoples	(COLU)
BLOOM	64	PL 8 87	S. Bloom <i>et al.</i>	(CERN)
DUCLOS	64	PL 9 62	J. Duclos <i>et al.</i>	(CERN)
GUREVICH	64	PL 11 185	I.I. Gurevich <i>et al.</i>	(KIAE)
BUHLER	63	PL 7 368	A. Buhler-Broglin <i>et al.</i>	(CERN)
MEYER	63	PR 132 2693	S.L. Meyer <i>et al.</i>	(COLU)
CHARPAK	62	PL 1 16	G. Charpak <i>et al.</i>	(CERN)
CONFORTO	62	NC 26 261	G. Conforto <i>et al.</i>	(INFN, ROMA, CERN)
ALI-ZADE	61	JETP 13 313	S.A. Ali-Zade, I.I. Gurevich, B.A. Nikolsky	
		Translated from ZETF 40 452.		
CRITTENDEN	61	PR 121 1823	R.R. Crittenden, W.D. Walker, J. Ballam	(WISC+)
KRUGER	61	UCRL 9322 unpub.	H. Kruger	(LRL)
GUREVICH	60	JETP 10 225	I.I. Gurevich, B.A. Nikolsky, L.V. Surkova	(ITEP)
		Translated from ZETF 37 318.		
PLANO	60	PR 119 1400	R.J. Plano	(COLU)
ASHKIN	59	NC 14 1266	J. Ashkin <i>et al.</i>	(CERN)
BARDON	59	PRL 2 56	M. Bardon, D. Berley, L.M. Lederman	(COLU)
LEE	59	PRL 3 55	J. Lee, N.P. Samios	(COLU)

---